FUNDY TIDAL POWER

STAGE 1

Report of

ALCAN ALUMINIUM LIMITED

to the

TIDAL POWER CORPORATION

December 1978

Alcan Aluminium Limited

1188 Sherbrooke Street West, Montreal, Quebec, Canada, H3A 3G2
Telephone: 514 848-8000 • Telex: 05-25236 • Cable: ALCAN

27 November 1985

Mr. Ronald Barkhouse
President
Tidal Power Corporation
Suite 1109
5251 Duke Street
Halifax, Nova Scotia
B3J 1P3

Dear Mr. Barkhouse:

It is our pleasure to submit the results of the investigation just completed on the technical, financial and commercial aspects of a major tidal power scheme in the Bay of Fundy.

The program was carried out by a team which represents expertise and experience in all facets of a project of this kind. The cooperation and aid rendered by Mr. George C. Baker and other members of your Board were of inestimable value.

We feel we have identified the most suitable and feasible initial development and we believe we have ascertained what conditions will be necessary for its realization.

Repectfully yours,

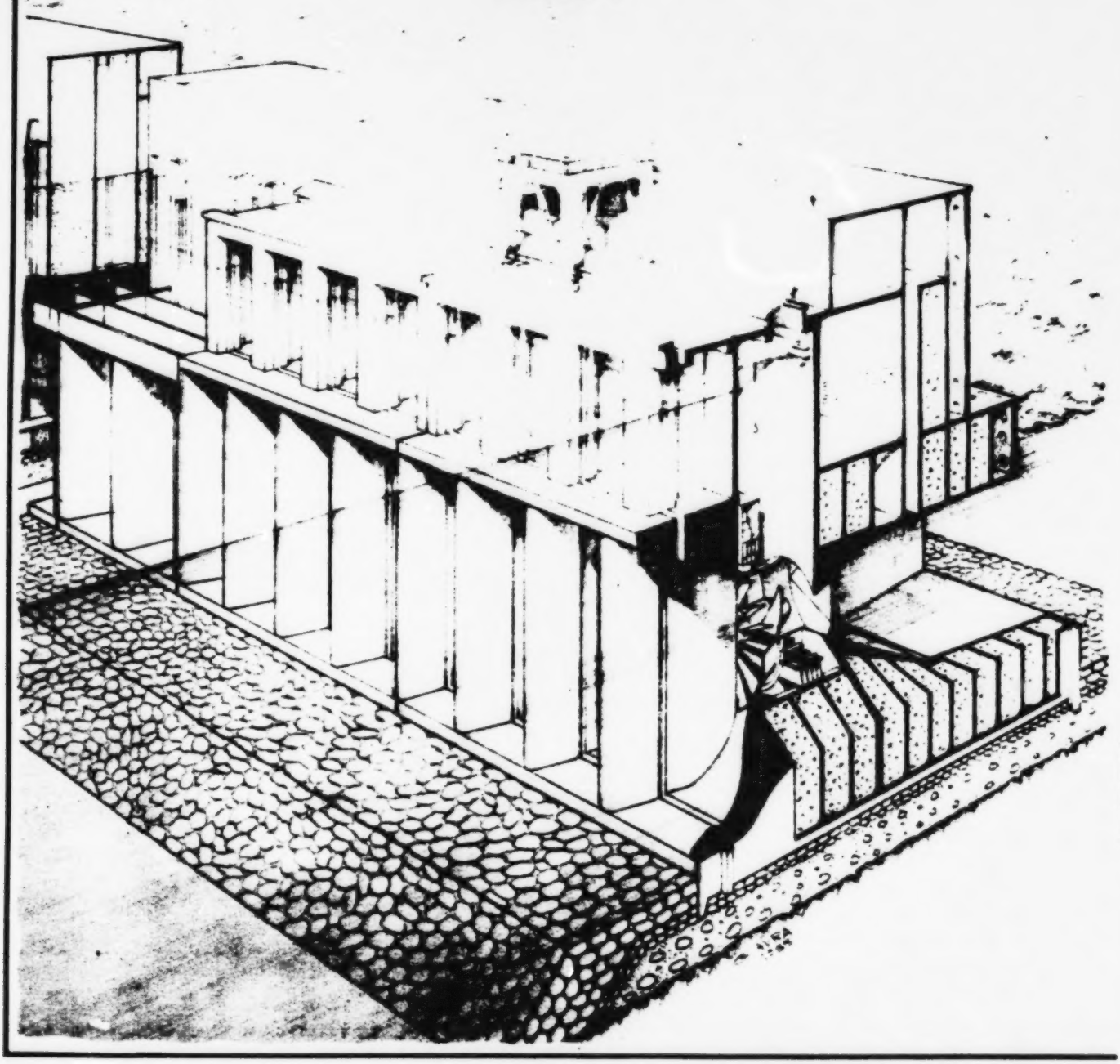
Murray D. Lester

Murray D. Lester

MDL:RS

FUNDY TIDAL POWER

STAGE 1



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INTRODUCTION

Background

The tides of the oceans have long been harnessed to yield useable energy, generally in modest water mills providing mechanical motion. With the advent of electricity, it became possible to consider utilizing tidal flows on a much larger scale by converting impounded water into electric power, as in a conventional hydro station.

But the fundamental source of the tides has been its most serious handicap. The lunar/solar forces responsible for tidal movement impose a natural rhythm which generally leads to two complete cycles of ebb and flow about every twenty-four hours and fifty minutes. The resulting power generation is correspondingly cyclic and, therefore, not in the form of the firm dependable capacity most useful to a typical power system. Nevertheless, the economic and environmental problems that are associated with most of the conventional means of producing electricity have served to maintain a continuing interest in the prospect of tidal power at those sites around the world which are known to be technically favourable.

Geographical locations which appear to offer the right combination of tidal ranges and topographical configuration are found in France, Korea, China, Soviet Union, India, England and Northern Ireland, among others. But perhaps the most impressive sites are those in the Bay of Fundy, where more than thirty different technically feasible projects have been identified.

Previous Fundy Studies

While this region has been the object of investigations going back at least seventy years, the most comprehensive investigations were those of the Atlantic Tidal Power Programming Board in 1967-69; the Tidal Power Review Board in 1976-77 and an update of the latter by the Tidal Power Corporation of Nova Scotia in 1981-82. Two recent papers (Ref. 1 and 2) describe the findings of these studies.

In brief, the 1967-69 program carved out the first systematic assessment of the various possible schemes in the Bay of Fundy. It concluded that, based on then existing cost factors and on certain financial assumptions, tidal power was uneconomic at that time.

The 1976-77 program re-assessed about thirty sites and narrowed these down to three for more detailed evaluation. They were Site A6 in Shepody Bay; Site A8 in Cumberland Basin; and Site B9 in Minas Basin. For a number of reasons which will be discussed later, Site A8 was singled out as the most suitable and was recommended for further study to verify its apparent economic and technical viability. This choice was strongly influenced by the policy objective of retaining a significant portion of the power output within the Maritime provinces. (The ostensibly more cost-effective Site B9 would produce too much energy to meet that objective.)

In 1981-82, in the light of changes in the energy world and in market conditions, an update of the 1976-77 examination indicated that both Sites A8 and B9 were now attractive and competitive. The latter was assessed to be more favourable, on the assumption that nearly all of its large output would be marketable in New England and/or New York, but it was recognized that the very high capital investment requirement would impose difficulties.

The update report concluded that "...If further progress toward the realization of a tidal power development is deemed to be warranted, a precommitment program should be undertaken...". The very high cost of such a program remained an inhibiting factor. Meanwhile, however, the emergence of improved technology and its demonstration at Annapolis Royal served to sustain interest in Fundy.

Annapolis Royal

During the 1970's, considerable improvements were devised for a long-known type of hydraulic turbo-generator in which the generator rotor

was mounted on the periphery of a horizontal-axis turbine. This "Straflo" design showed promise of being more cost-effective for relatively low-head hydro sites (like tidal) than the more conventional bulb turbines which, for example, had been installed in 1966 at the world's only existing major tidal power facility, the 240 MW plant at La Rance in France. Canada has numerous potential low head hydro sites and the Straflo turbine could be manufactured domestically at existing facilities. In light of these and other considerations, agreement was reached between the Province of Nova Scotia and the Federal Department of Energy, Mines and Resources to share the cost of a 20 MW demonstration power plant. The site selected was at Annapolis Royal, located at an existing causeway across the Annapolis River, near its outlet into the Bay of Fundy. This plant (Ref. 3) includes a single Straflo turbine-generator of about the same dimensions (7.6 m diameter) as might be used in a multi-unit large project functioning at a somewhat higher head and output.

The station was commissioned in August 1984 and has been operating quite successfully. Of particular interest will be the monitoring over the coming years of the unit's operating history and its repairs and maintenance record.

The Rothschild Initiative

Mr. Edmund L. de Rothschild of the British merchant bank N. M. Rothschild & Sons Ltd. had played a major role in the Churchill Falls power development in Newfoundland and continued a strong interest in the subject of Canadian hydro power. He had also formed a company (Straflo Limited) for the purpose of promoting and encouraging the use of Straflo turbines. In October 1982 he prepared a document entitled "Concept of an Idea to Further the Development of the Bay of Fundy" (Ref. 4). It urged that a private sector consortium of Canadian, U.S. and U.K. firms be organized for the purpose of pursuing a major Fundy project dedicated to exporting power to the U.S. Following discussions at various government levels, Mr. de Rothschild proposed that Alcan Aluminium Limited be invited to lead the program. Because of its long experience in the building and

operation of large hydro projects, its background in the purchase and sale of power, and its relationships with various government departments, Alcan was perceived to be the logical Canadian private sector entity to undertake the task.

Alcan's Role

Alcan agreed to outline the terms of reference under which it would proceed. Mr. Murray D. Lester, Vice President, Energy Resources, assumed this responsibility and was assisted by Mr. Anthony G. Hillier, Director, N. M. Rothschild & Sons Limited.

After several months of reviewing the previous studies and discussing the matter with relevant officials, Alcan came to a preliminary conclusion that Site A8 might be the only viable choice for the first commercial Fundy project. The reasons that led to this finding in the 1977 Reassessment were deemed to be still valid, viz:

1. The project, while substantial, is the smallest of the leading contenders, rendering it less vulnerable to fears of beginning with an extremely large development.

2. Its financing would be correspondingly less difficult as compared to the very large projects.

3. Its environmental impact would be significantly less severe, particularly in the sensitive aspect of increasing tidal amplitudes on the U.S. coast.

4. The project would link Nova Scotia and New Brunswick whereas Site B9, for example, would lie entirely within Nova Scotia. As a bi-provincial development, the A8 Project could gain more Federal and public support than a strictly provincial installation.

On the strength of some very preliminary updating of earlier numbers, Alcan conjectured that the capital investment and the energy production associated with an A8 Project could yield a power cost competitive in the New England marketplace. A three stage program was then proposed to bring a major Fundy tidal power project to fruition by the mid-1990's. At about this time, the Bechtel organization in San Francsico was given the background material and was asked to comment on our proposal. Their reply (Ref. 5) states that "...We believe that the Bay of Fundy Tidal Project is technically feasible and we endorse the approach you intend to follow to develop the project...".

The Three Stage Program

Because the support and collaboration of the Federal government would be required in nearly all aspects of such an undertaking, Alcan arranged discussions and briefings from the beginning with various senior Federal officials in the relevant departments. A letter (Ref. 6) to Mr. G. F. Osbaldeston, Secretary to the Cabinet, was drafted for the purpose of outlining Alcan's suggested program and describing the conditions under which Alcan would agree to act as leader and administrator. The program was divided into three stages:

Stage 1: Feasibility Update Alcan would sponsor further studies aimed at determining more closely the technical and economic aspects of the A8 site. Then, on the basis of the resulting figures, an early approach would be made to the potential New England utility customers in order to ascertain the extent of interest from that quarter. At the same time, presuming the signals were favourable, the team would pursue the concept of putting together a syndicate or consortium of corporate investors to form a Fundy Development Corporation aimed at carrying out Stage 2. It was felt that to accomplish such a syndication, one of the major requirements would be a Letter of Intent from the Federal government in which the government's position on several points would need to be established:

1. The granting of long-term exclusive water rights at the selected site.
2. The granting of power export licences for an appropriate time period.

3. Guarantees for the repayment of loans during the construction period.
4. A financial stand-by to the developers to enable power contracts to be negotiated at a price protected against possible delays and cost overruns during construction.
5. Certain other provisions whereby the investors would be bought out in the event rights or licences were withdrawn and the project abandoned, or if it were deemed that a completed project should be entirely in the public hands.

Stage 2: Pre-Construction Program Assuming positive indication from Stage 1, the Fundy Development Corporation would be constituted and would embark on the three to four year program required to bring the project to the point of starting construction. Among the activities during this phase would be the following:

1. Acquiring the necessary permits, licences and approvals.

2. Undertaking the engineering and environmental studies and designs.

3. Establishing the corporate structure and capitalization of the entity that would construct, own and operate the project.

4. Arranging the financing.

5. Negotiating the power sales contracts.

It was envisaged that the estimated $50 million to $100 million required to undertake Stage 2 would be subscribed as equity by the syndicated private companies forming the Fundy Development Corporation. Their funds would be at risk if the project did not proceed owing to economic, legal or technical impediments identified during the Stage 2 phase. The essence of the proposal was that, in return for these risks, the corporate investors would be granted the Letter of Intent described earlier.

Stage 3: Construction and Operation Assuming favourable and successful findings in Stage 2, it was expected that a Fundy Power Corporation would be established to undertake, as owner, the financing, construction and operation of the project. Actual ownership could consist of some agreed proportioning among Nova Scotia, New Brunswick, the Federal government, the corporate investors in Stage 2 and, possibly, the public.

Program Funding

The balance of 1983 was taken up by numerous discussions between the Study Team and Federal officials, mostly centered on the question of obtaining the Letter of Intent mentioned above. The draft letter (Ref. 6) was rewritten a number of times. In essence, the Federal view (Ref. 7) was that they supported Alcan's planned pre-feasibility program and would assist in legal and regulatory matters but they felt it was premature for a Letter of Intent offering financial back-up along the lines proposed by Alcan. Because Alcan was reluctant to sponsor Stage 1, either financially or administratively, without the enthusiasm and support it felt needed to be shown by the Federal government, an impasse lasting several months resulted.

Finally, toward the end of 1983, a compromise was reached wherein the Stage 1 program would be administered and managed by Alcan but would be financed by funds made available from the Canada-Nova Scotia Oil Substitution and Conservation Agreement. Letters to this effect were exchanged (Ref. 8, 9, 10, 11) between the Federal Minister of Energy Mines and Resources; the Nova Scotia Minister of Mines and Energy; and the C.E.O. of Alcan.

PROJECT BRIEF

In January 1984, a Project Brief (Ref. 12) outlining the terms of reference was prepared by the Tidal Power Corporation of Nova Scotia and signed by Alcan. The objectives of the Stage 1 were stipulated as follows:

1. Determination of optimum design, related energy output and current estimate of capital cost for selected sites.

2. Selection of a specific project as a development target.

3. Calculation of the generating costs, transmission costs and the amounts and timing of the revenues required to attain financial viability for the selected project.

4. Determination of the commercial viability of tidal energy output in the light of the calculated financial criteria.

The Stage 1 program commenced at once, following the signing of the Project Brief. As a first step, a Study Team was organized to deal both with the overall administration of the work and the specialized aspects that would be involved. It consisted of the following personnel:

M. D. Lester	(Alcan)	Study Manager
H. Roth	(Alcan)	Financial Liaison
R. H. Lalande	(Consultant)	Commercial Liaison
J. T. Madill	(Consultant)	Technical Liaison

TECHNICAL STUDIES

Organization

The initial priority was to engage a consulting firm to provide the basic data called for under Objective (1) noted above. For this purpose an agreement was reached with Tidal Power Consultants Limited (TPCL), a Montreal-based consortium comprising Shawinigan/Lavalin and Montreal Engineering, with lesser participation by Harza (USA) and EPDC (UK). TPCL had undertaken some of the key tasks of the 1977 Reassessment Report and had also served as consultant for the 1982 Update Report. Mr. E. van Walsum, Vice President and General Manager of TPCL, was named as director for the new Alcan assignment.

As sub-consultants to TPCL, the following firms also assisted in the technical studies and investigations:

Wilson Energy Associates Ltd., Stockport, England
- energy production calculations

Dominion Bridge Sulzer Inc., Lachine, Quebec
- performance and cost of turbine-generators

Brown Boveri Canada Inc., Montreal, Quebec
- performance and cost of HVDC equipment

Both Belle Robb Ltd., Montreal, Quebec
- construction methods, schedules and costs

Findings (A8 Site)

The findings of TPCL are covered in their two volume report to Alcan attached hereto as Appendix I. The results of their investigation and study of the A8 site can be summarized as follows:

Dam Total length of 2,560 m including 820 m of powerhouse, 400 m of sluiceway and 1,340 m of dyke.

Power Plant An installed capacity of 1,428 MW, consisting of 42 units of 34 MW each. The turbine-generators would be of the Straflo design, assuming that the prototype Annapolis Royal unit proves successful over a number of years of experience. The turbines would be 7.5 m in diameter, with fixed blades and variable distributor (wicket gates). The generators would operate within a speed range of 35 to 73 rpm, developing their full 34 MW rating under the maximum head of 9.1 m.

Transmission For the assumed sale of the power to the New England Power Pool (NEPOOL), the optimum transmission arrangement was determined to be High Voltage Direct Current at +/- 450 KV. Power would be rectified to DC at the power station and inverted back to 345 KV alternating current at Ludlow, MA. The line would be about 860 km long, including 500 km in the U.S.A.

Power Production Full power would be available in the eighth year after notice to proceed and, after allowing for transmission losses, would amount to about 3,307 GWh per year of net energy received. The annual capacity factor of the power station comes to about 29%, the relatively low figure resulting, of course, from the cyclic nature of tidal power.

Capital Cost The A8 Project is estimated to cost Can.$2,560 million, in 1984 terms, without allowance for interest during construction. Of this total, about $668 million is accounted for by the transmission and related terminal facilities.

Findings (B9 Site)

The principal object of the technical studies was to bring the analysis and evaluation of the A8 project up to the previously-established level of the B9 project. In so doing, advantage was obviously taken of the most recent techniques and technology - from the viewpoint both of construction methods and of energy output optimization. This afforded an opportunity to re-examine the earlier B9 concept in light of the newer approaches. The findings of TPCL are as follows:

Power Plant An installed capacity of 5,338 MW, consisting of 128 units of 41.7 MW each. The turbine-generators would be of the Straflo design, assuming that the prototype Annapolis Royal unit proves successful over a number of years of experience. The turbines would be 7.5 m in diameter, with fixed blades and variable distributor (wicket gates).

Transmission As described above for the A8 Site, but with proportionately greater capacity.

Power Production Full power would be available in the eleventh year after notice to proceed and, after allowing for transmission losses, would amount to about 13,780 GWh per year of net energy received. The annual capacity factor of the station comes to about 31%, for the same reason as noted earlier.

Capital Cost The B9 Project is estimated to cost Can.$7,000 million, in 1984 terms, without allowance for interest during construction. Of this total, about $1,200 million is accounted for by the transmission and related terminal facilities.

Relative Economics of the Sites

It is clear from the foregoing that, based only on power output achievable per dollar invested, the A8 Project is less cost effective than the B9 Project. For example, taking the raw figures for each site, we obtain for A8 an index of Can.$0.77 per KWh/year while for B9 the corresponding ratio is $0.51. This apparent 33% margin in favour of B9 must, however, be considered in the entire context of Fundy. For reasons discussed previously, including the bi-provincial factor, environmental impact considerations, and sheer size for an initial venture, the A8 Project is deemed to be the most achievable scheme among the many variants that have been examined in the past. This was borne out later during the course of the commercial investigations. However, the B9 will remain a most attractive possibility for the future if and when circumstances or experience gained on prior projects render it feasible.

An additional aspect worth noting is that, in terms of the capital costs for the power station alone, both the A8 and B9 sites yield figures (Can.$1,325 and $1,087 per KW installed, respectively) that are very near the low end of the range being achieved in the world today in the hydroelectric field. This indicates that, from an engineering point of view, the installations are relatively simple and do not involve costly procedures. However, this economic advantage is offset by the low capacity factor due to the tidal cyclicity and by the high cost of the transmission facilities to a distant market.

Environmental Aspects

Detailed considerations of environmental impact are beyond the scope of the present program but, nevertheless, an early appreciation of this subject is necessary.

A number of government departments has been involved in these studies over many years, led by the Bedford Institute of Oceanography (where the Study Team had a one day briefing session) and coordinated by an ad hoc body, the Fundy Environmental Studies Committee of the Atlantic Provinces Council on the Sciences. A recent paper (Ref. 13) describes the possible benefits and problems that may be expected in connection with a major Fundy Project.

In brief, three types of concerns will need to be addressed. These are (a) fish mortality - the effect on migratory shad passing through the turbines; (b) effects on the Gulf of Maine Fishery; and (c) effects on coastal water levels along the regional shoreline. The latter question has been modelled mathematically and it had been tentatively estimated that a B9 Project would increase the tidal amplitude by about 13 cm at certain key coastal locations while the effect of the A8 Project would be about 3 cm. The difference between the two estimates is considered to be a possibly crucial factor in site selection for a first major project. More recently, it has been conjectured that both of these figures may prove to be overly pessimistic. Nevertheless, it is clear that the environmental

impact of the A8 site will be less than that of B9. As noted earlier, this fact strengthens the case for focussing on A8 at this time.

Qualitative Observations Regarding the Technical Studies

1. The principal consultants, TPCL, brought considerable knowledge to the program particularly in view of the fact that a number of the key personnel had previously been associated with the 1977 and 1982 efforts. Their selected sub-consultants were an additional source of strength, as noted below.
2. Wilson Energy Associates have had prior experience in developing the analysis of other tidal projects, including the very large Severn Estuary scheme in the U.K. Their calculations of Fundy energy output figures are based on sophisticated techniques.
3. Dominion-Bridge Sulzer Inc. provided performance data and costs for the turbines, with the help of Escher Wyss of Switzerland. Thus, both the designer and supplier of the Straflo unit at Annapolis Royal were involved.
4. Brown Boveri Canada Inc. were backed by the research and resources of their Swiss parent company in providing HVDC data.
5. Both Belle Robb Ltd., a highly-experienced firm in the areas of project organization, construction methods and cost estimating, undertook a complete re-examination of how the project should be built in order to arrive at a fresh new estimate based on up-to-date techniques. Distinctions were made on contingency factors, as a function of the degree of confidence in assessing different kinds of work, and probabilities were applied to various elements of uncertainty.

In general it is believed that the technical studies are founded on the best abilities available in each field and that the construction methods are well-conceived. The resulting cost estimates must be accepted as the most reliable produced to date.

FINANCIAL STUDIES

Organization

Arrangments for the second major component of the Stage 1 Program, the financial studies and analyses, commenced in the summer of 1984. While awaiting the specific cost and energy data from the technical investigation, the Study Team engaged the services of the First Boston Corporation of New York, a banking house with substantial experience and background both in the electric utilities sector and in the New England/Eastern Canada geographical regions.

Discussions with Mr. C. W. Beale, Managing Director, led to an exchange of letters (Ref. 14, 15) describing the terms of reference and scope of the task to be done. In brief, these comprised:

1. Recommending a business structure for the Project which would accommodate corporate, utility and/or governmental equity investors, as well as lenders.

2. Making judgments on a required rate of return for equity investors.

3. Making judgments on the degree to which the Project can be leveraged with non-recourse debt and the debt maturity and repayment schedule which could be achieved.

4. Constructing a computer model to determine a range of prices at which power would be sold to U.S. utilities under various assumptions for interest rates, degrees of leverage, and other key variables.

The personnel named to carry out the work were:

F. M. Dunlevy, Vice President, Corporate Finance
P. M. Huyck, Director, FB Alternate Energy Corporation
D. R. More, Associate, Project Finance Group

In November 1984, First Boston was given (Ref. 16) the basic cost and energy data that had just been calculated by the technical studies group and agreement was reached on the initial ranges of the variables that were to be used.

Findings (A8 Site)

The two parts of Appendix II constitute the findings of First Boston. Part 1 contains the charts and graphs covering the many permutations of the assumed variables and the effect on the project's economics of changes in any one variable. Part 2 focuses on four particular combinations of assumptions and gives the year-by-year cash flows for each of these cases.

The FB computer has been programmed to yield Return on Equity as the product or output of each set of variables being tested. This would not have been our preference; it would be considerably more convenient if the end product of each run was the Power Price resulting from the values assigned to the variables. Nevertheless, the material in Appendix II does cover all the realistic variations that might occur and constitutes a valuable tool which will not become obsolete.

At the outset, it was assumed that a certain portion of the capital would be in the form of equity. The power price for most of the permutations considered is very sensitive to the selected debt/equity ratio and, particularly where income tax is assumed applicable, tends to drive the required revenue figure to high levels. Similarly, the assumed interest rate on the debt portion is a very major factor in establishing the required power price. In fact, the interest rate question is at the core of the financial/economic assessment of the Fundy Project as is almost always the case with any capital-intensive undertaking.

The uncertainties still surrounding the future course of both inflation and interest rates make any long-term projections at best conjectural. Instead of attempting to bracket the impossibly wide range of scenarios that would need to be examined, it was decided to carry out the financial/economic

analysis of the project on the basis of true economics, i.e., by working only with "real" interest rates of return.

The actual interest rate demanded by the marketplace at any time is frequently described as the sum of two components: a so-called real rate of interest which represents a true return on capital and has historically ranged between 3% and 4%, and an inflationary factor which makes up for any erosion in the actual value of money. Thus, during those periods in history when inflation was zero, long term financing (say, government or AAA corporate bonds) was normally obtainable at 3% to 4% interest rates. During the high inflation years of the late 70's and early 80's, nominal interest rates in many currencies, including U.S. and Canadian dollars, reached levels in the 12% to 15% range. (Even these rates did not always provide a real return to the lender.)

Inflation has since subsided and today appears to have, at least temporarily, stabilized at about 4% p.a. In theory, if nominal or actual lending rates reflect the sum of the basic real return of 3% to 4% and the inflation adjustment, then today's lending rates ought to be in the 7%-8% range. In fact, however, actual rates are still up at around 11%. The conventional explanation of this apparent anomaly is that lenders are wary about a possible resurgence in inflation (stimulated, for example, by excessive national deficits) and are protecting themselves by demanding higher-than-traditional returns. At the same time, there is a body of opinion which maintains that if inflation remains under control, actual rates will revert to the historical rule and will again conform to the pattern indicated above.

Be that as it may, we are faced here with the need to stipulate an interest rate for financing a project which could not be started for at least three years and not be completed until the mid-1990's. We instructed the financial team to use real interest rates of 4%, 6% and 8% in their analyses. The present actual lending rate of about 11% is, however, a reality and implies a real rate of return of about 7%. While, as noted above, such a real rate is not felt to be tenable over a long period, it does have the immediate impact of rendering low running cost but high capital-cost

projects unattractive in comparison with alternatives that provide the same function but at a lower up-front investment and high subsequent running costs. To illustrate this, First Boston also examined and reported (in Part 2 of Appendix A) the effect of a nominal lending rate of 12%.

The numerical results of First Boston's financial models can be summarized as follows:
At an assumed debt/equity ratio of 80%, and at interest rates of 4%, 6% and 8% (with proportionately higher returns on the equity), the corresponding levelized power prices needed to amortize the debt in 25 years work out to be about U.S. 4 cents per KWh, 5-1/2 cents and 7-1/2 cents, respectively. If the equity return were taxed at 50%, then the power price figures would need to be increased by 10%-15% to maintain the after-tax return. If the financing were 100% debt, then the power prices would need to be about 3.8 cents, 4.3 cents and 5.8 cents, respectively, in order to amortize the debt at the 4%, 6% and 8% interest rate levels. At the other extreme, a 12% interest rate, with financing in the form of 100% debt, leads to a levelized power price of about 13.2 cents.

Findings (B9 Site)

A number of comparative calculations were carried out for the B9 site, using the same general guideline criteria as for A8 but, of course, substituting the energy and cost data that TPCL had worked out for B9. As would be expected, the previously-noted cost advantage of B9 manifests itself in the results of the financial analysis. All other things being equal, the power price from a B9 project would be up to 30% lower than from the A8 project. Again, however, this ignores the issues of environmental impact and sheer size and capital cost - issues which we believe render A8 as the most feasible initial development.

Implications

The prospect of A8 producing power at a real cost of about 4 cents per KWh while at the same time providing the lenders with a real return on investment which matches historical levels appears to be prima facie quite

interesting. However, for this situation to materialize, one of two things must occur:

a) The inflation rate in the U.S.A. and Canada would have to diminish to nearly zero and do so in a context in which interest rates on long term debt reverted to their historical real levels of about 4%, or

b) Financing would have to be arranged at an index-linked interest rate consisting of a real component of say 4%, plus an inflation component equal to the current year's inflation rate. In order to service this type of debt, the power revenues from the project in question would need to be proportionately responsive to changes in the total interest rate. This concept of index-linked financing did, in fact, emerge during the course of the program and will be discussed later.

Observations of the Financial Consultants

While First Boston's principal role was to calculate the prices and costs associated with various permutations of variables, they did offer comments (Appendix II, Part 1, Schedule I) which are not dissimilar from the aforementioned implications:

> "Capital markets in recent years have exacted a real interest rate substantially above historical levels. The impact of this high real interest rate environment on the Bay of Fundy Project is unfavourable. It does not permit the low long-term operating costs of the Project to compensate fully for the high capital cost and long construction period. The present high real interest rate environment distorts the perception of the long-term value of the Project. If we were to return to a more normal real interest rate, the appeal of the Project would be substantially enhanced..."

> "...If real interest rates drop back to historical levels of 3%-4%, the Project could become feasible. The problem now is whether to commit for three years of engineering studies...in hopes of a change in perceptions of inflationary trends and the relationship between inflation rates and nominal interest rates."

These remarks preceded the actual discussions later undertaken with the potential marketplace and do not take into account either the possible improvement in the quality of the power (through re-timing) or the possible technique of index-linked financing.

COMMERCIAL STUDIES

Background

For a number of years prior to this program, it had been presumed that most, if not all, of the electricity produced by a major Fundy project could be sold and, in fact, would need to be sold across the border in the northeast U.S. in order to render the scheme economically feasible. The underlying logic had been that:

a) A large Fundy installation would generate much more power than needed in the Maritime Provinces;

b) The cyclicity of the output is such that only a large power system, like New England, could effectively accept peak tidal output when it occurs during slack demand periods; and

c) Only a large oil-burning system, like New England, could afford to pay the relatively high price for tidal electricity as a fuel substitute.

These premises were accepted as valid at the outset of our investigation; for reasons that will be treated later, it turned out that none of them are entirely true.

The New England Market

Almost all of the power supplied by the public and private utilities of this region is scheduled and dispatched by the entity known as the New England Power Pool (NEPOOL). In their latest forecasts (Ref. 17) NEPOOL sees the system peak demand rising from today's 16,400 MW to a figure of 20,800 MW in 1995. Over this same period, the annual energy requirement will increase from about 92,000 Gwh to 120,000 Gwh. In 1995 at least 20% of power output and perhaps considerably more, is expected to be based on oil. The uncertainty is based not only on the usual problem of

predicting loads but also on the fact that the present major alternatives - nuclear and coal - are beset with difficulties of their own.

In the words of Massachusetts authorities (Ref. 18):

> "New England's long-run electricity supply and situation will be a serious problem if the status quo continues. The region is now paying the price for its utilities putting nearly all of their eggs in the nuclear basket... There are readily available solutions which in the long-run will have to be implemented."

That report goes on to list a "menu of solutions" in order of increasing desirability or feasibility, as follows:

> "1. Importation of electricity from cheap coal plants in the Midwest U.S.
> 2. Build one or more coal plants.
> 3. Purchase of power or capacity from Canadian nuclear plants.
> 4. Purchase power from Hydro Quebec beyond present plans.
> 5. Build other small baseload power plants.
> 6. Build little diesel peaking units.
> 7. Extend the operating lives of existing plants.
> 8. Encourage third party small power production and co-generation.
> 9. Place more emphasis on load management and conservation."

This list does not refer to the possible import of Fundy tidal power, largely because we had not yet approached NEPOOL on this subject and there was no reason for them to think that any further steps had been taken since the 1982 Update report.

This then was the situation awaiting us as we prepared to initiate discussions. A meeting of the Study Team, the outside consultants, and representatives from Tidal Power Corporation and New Brunswick Electric Power Corporation was held in Montreal in February 1985 and agreement was reached on the text of the initial approach to NEPOOL.

The 8 March 1985 Letter to NEPOOL

This letter, and several subsequent ones, are reproduced here in their entirety because of their significance to the entire program.

ALCAN ALUMINIUM LIMITED

8 March 1985

Mr. Philip C. Otness
Executive Director
New England Power Pool
174 Brush Hill Avenue
P.O. Box 10
West Springfield, MA 01090

Dear Mr. Otness:

During the past year, a new investigation of a major tidal power project in the Bay of Fundy has been undertaken. This study, financed through a Canadian Federal/Provincial Agreement, is being coordinated and administered by Alcan Aluminium Limited under terms of reference worked out with the Tidal Power Corporation of Nova Scotia.

Alcan's leadership was requested by both levels of government because of a general desire to introduce the private sector point of view into the analysis of a project which, in one form or another, had been studied on numerous occasions in the past but perhaps without sufficient reference to the financial and utility marketplace. Our involvement was sought because of our wide experience in the development and operation of very large hydroelectric installations and our broad background in the purchase and sale of large blocks of power and energy in all parts of the world. Our acceptance of this management role is in no way related to any use of Fundy tidal power for aluminum smelting.

In the course of implementing this program, we have engaged a number of consultants and experts. The technical studies were carried out by Tidal Power Consultants Limited, a company of well-known engineering firms with considerable previous experience in this field. Our financial adviser is First Boston Corporation of New York, with additional counsel from N.M. Rothschild & Sons Limited of London and Mr. Edmund L. de Rothschild. We have also been drawing on various other consultants in the engineering and utility fields as well as on several major suppliers of hydroelectric machinery and equipment.

It has been said that over half of all the major potential tidal power sites in the world lie in the Bay of Fundy. What we have focused on in this current program is a specific project for which we have estimated the investment costs and the energy output, in light of up-to-date construction and operating techniques. This installation is not the largest single site that could be developed nor is it necessarily even the most economic, on a unit cost basis. However, it seems to offer an optimum combination of size and location which suggests that it may well be the

most feasible venue for the first major installation in the Bay. Success here would likely lead to further developments at other Fundy sites.

The principal market for this new power source is, logically, the New England region with a minor portion possibly remaining in the Maritimes. For purposes of this present study we have assumed a dedicated HVDC supply delivered at Ludlow, MA. Under this concept, we envisage that the power will be exported at a price related directly and only to the actual cost of service. The quantity of energy delivered will, of course, be eminently predictable over any time period, not being dependent on hydrologic events. Moreover, thanks to the multiplicity of generating units, it will be much less vulnerable to unplanned outages.

It has been suggested that New England may find it advantageous to think in terms of diversifying its future Canadian power imports. A supply from a Fundy Tidal Power Station could not commence before the mid-90's in any case, a point in time when some of your then-existing import arrangements may be nearing their end. We have maintained contact with Hydro-Quebec throughout our investigation and are pleased to say that they view Fundy power as complementary and sequential to their own export plans. Moreover, it has been noted that the energy banking arrangement incorporated in your recent contract with them could provide a very convenient and mutually profitable means of re-timing tidal power if and when necessary, thereby enhancing its usefulness on the load curve. By means of such banking, supplies from Fundy could, in effect, serve as new firm capacity.

The dam involved in our concept would link New Brunswick with Nova Scotia and both Premier Hatfield and Premier Buchanan have been encouraging our efforts. Moreover, there may well be an opportunity to structure a package which would combine Fundy tidal power with other sources in the Maritime region, leading to an integrated generation and transmission arrangement more advantageous to all parties than any single component.

As you are undoubtedly aware, a dedicated export of the kind envisaged in our study must obtain National Energy Board approval. In addition, the requirements of a number of Federal and Provincial government departments, regulatory agencies and licencing bodies will need to be addressed in the process of designing and building the project. We have reason to believe that a spirit of cooperation will prevail in this regard and that, equally, no insuperable problems will emerge on the U.S.A. side.

We are now at a point we had envisaged when we first set out on this investigation. We need to ascertain the extent of interest on the part of the New England electric utilities. Rather than talking to individual companies, it seems appropriate to open a dialogue with NEPOOL. What we would like to propose is a visit by a small party from among our group, including myself, one or two senior people from First Boston and perhaps one or two other associates in the program.

At such a meeting we would describe our present concept from the viewpoint of size, costs and timing. We would then relate these factors to the corresponding power revenue requirements under various financial and regulatory scenarios - including both present and possible future conditions.

Whether a major Fundy Tidal Power Project ought to get under way tomorrow; in the near future; or in a more remote time frame, is a conclusion yet to be reached. We have taken the first small step toward an eventual development but it seems clear that no further progress could nor should be made until the proposed customers, the receiving utilities, have been informed of the project and have indicated how they view the opportunity.

This letter has been rather lengthier than expected but I did want to set the stage properly for meeting with you and your associates. Our schedule calls for such discussions to take place between now and the end of April. I would appreciate very much if you would contact me in order that we may work out a mutually convenient date.

Yours very truly,
Murray D. Lester

Copies of this letter were also forwarded to the National Energy Board, because of their expressed interest in being informed of progress, and to Hydro-Quebec. The latter had been apprised of the program almost from its inception because of the numerous ways in which a major Fundy project could affect or be affected by Hydro-Quebec. A letter to Hydro-Quebec in February 1983 (Ref. 19) described why Alcan was considering the present program and invited Hydro-Quebec's cooperation. A year later, they were informed that the program was getting under way and were given an outline of the various phases (Ref. 20). At about this same time, the New Brunswick Electric Power Commission (which had been designated by the Premier to represent that province's interests) was also formally brought up to date and invited to participate in all future activities (Ref. 21).

Meanwhile, to better understand the size and nature of New England's existing and planned power imports from Hydro-Quebec, an internal report was commissioned and prepared (Ref. 22), along with a map showing the existing and planned transmission linkages between Quebec, New Brunswick

and New England (Ref. 23). Of particular interest was the possibility that the normally cyclic output from a Fundy project might be re-timed into a much more useful pattern of a firm levelized power supply by means of the large hydro plants and reservoirs in Quebec, using the interconnections for the necessary energy interchange.

The Index-Linked Financing Approach

While awaiting a response from NEPOOL to our 8 March letter, we were briefed by Burns Fry Limited on their current effort to introduce index-linked financing into Canada on a large scale as a source of major project capital. In Britain, the marketing of government bonds of this type had been successfully carried out since 1981. In connection with a possible application of this approach for a Fundy Tidal Power Project, Burns Fry stated (Ref. 24) that:

> "We at Burns Fry are very confident that we could place privately with major Canadian financial institutions sufficient index-linked 25 to 35 year long-term obligations to finance the $2.5 billion Bay of Fundy of Fundy Tidal Power project... The real rate of interest would be about 4% plus or minus 1/4% depending upon the nature of the power sales contract, the availability of government guarantees and the term to maturity."

They pointed out that pension funds are expressing keen interest because their purchase of such bonds would assure them of a long-term real return concomitant with their normal actuarial obligations. An initial issue of index-linked bonds by the Federal government would be very helpful in establishing acceptability of the concept and, in fact, the Department of Finance had just solicited views on this subject from the financial and business communities (Ref. 25). As noted earlier, this mode of financing could well apply to Fundy under certain conditions.

All of the foregoing set the stage for the first meeting with NEPOOL.

The 23 April 1985 Meeting with NEPOOL Management

On this occasion, the Study Team met with Mr. P. C. Otness, Executive Director; Mr. R. J. Bolbrock, Director of Planning; and Mr. A. W. Barstow, Manager of Generation Plannning. Each party came away with food for thought. The Study Team learned for the first time that, notwithstanding NEPOOL's acknowledged future dependence on oil-fired generation, they are not anxious to secure tidal energy for oil replacement purposes because (a) their oil consumption could, during certain hours, not be sufficient to allow peak tidal power inflows to be utilized and, (b) the relatively steep growth and decay in each tidal cycle would cause operating problems in their system. Moreover, they perceive the already-planned 2,000 MW Phase II Interconnection with Hydro-Quebec as being a more convenient and economic means of obtaining fuel-replacement energy, even after the scheduled Year 2000 termination of the 7,000 GWh per year purchase contract. They foresee that until that date, this interconnection will be so heavily-loaded with incoming day-time energy that the idea of using it to re-time Fundy power will not be feasible.

On the other hand, however, NEPOOL stated that they were looking for new firm capacity by the mid-1990's. They expressed interest in the possibility of a strong second source of power from the Maritimes - either Fundy power re-timed through means other than the 2,000 MW Phase II Interconnection or even a larger block from Fundy and other sources, yielding both firm power and useable amounts of additional energy.

For their part, NEPOOL was given an explanation and description of the index-linked financing approach and its possible effects on power pricing. They had not had any occasion previously to consider this idea.

Both sides agreed to examine the issues that had arisen and to meet again in about two months. (More complete minutes of this 23 April meeting are given in Ref. 26.) We subsequently furnished NEPOOL with documentation on index-linked financing and turned to the matter of re-timing.

The Re-timing Question

In order to explore the possibility of re-timing A8 power by means other than the planned 2,000 MW interconnection between Quebec and New England, we met with senior officials of Hydro-Quebec on 13 June 1985. Hydro-Quebec was less than enthusiastic about providing capacity in order that tidal power be re-timed into a firm supply for New England - a region they see as more logically their own export market. They pointed out that they will have no redundant capacity in their system and that to service Fundy would require either an additional peaking unit at Manic 5 power station or, at even higher cost, a dedicated new pumped storage plant. They declared themselves neutral on the matter but would look into it further; a copy of the Technical Studies Report was left with them and further data was subsequently supplied. Fuller notes of this meeting are in Ref. 27. Further discussions on this subject were then held with the power authorities in New Brunswick and Nova Scotia. It became clear that re-timing could not be undertaken entirely within the Maritimes except by means of a new pumped storage station, which would be expensive, or a new compressed air/gas turbine facility, which has heretofore been successfully used only in West Germany at one location. However, New Brunswick was prepared to cooperate with regard to any arrangement that might be worked out with Hydro-Quebec, using the NB/HQ interconnection facilities totalling nearly 1,000 MW, including DC and radial AC loads.

The 17 June 1985 Meeting with NEPOOL Management

On this date, we reported to NEPOOL on Hydro-Quebec's cautious attitude toward re-timing. NEPOOL reiterated their own lack of interest in cyclic tidal energy as such and mentioned also that a new transmission line would face regulatory problems if it were operating at the low load factor associated with A8. It was noted that re-timed power could take the form of approximately 400 MW every hour of the year or 600 MW for sixteen hours every day or 800 MW for twelve hours every day or any equivalent combination. Moreover, they might consider waiving the re-timing service during Hydro-Quebec's critical period, such as January and February.

They again expressed interest in a long-term strong supply from the Maritimes, including future Lepreau nuclear units and one or more tidal plants. However, they pointed out that the regulatory environment in New England was not currently conducive to large-scale new initiatives. The problems of Seabrook Nuclear Station were still unsettled. Near future power supply problems could be handled by gas turbine installations or small coal-fired units. The fuel cost outlook was not as frightening as it had been. In light of this background, they had not pursued consideration of the concept of tying power prices to index-linked financing; this would be addressed if and when a suitable supply arrangement was shown to be feasible (Ref. 28).

The 21 June 1985 Meeting with NYPA Management

This meeting had been proposed by Mr. D. R. Ligon, a Washington, D.C. attorney with connections to both NYPA and the Province of Nova Scotia. It was attended by part of the Study Team; Mr. G. C. Baker; Mr. Ligon; and senior officers of the New York Power Authority (Ref. 29). As expected, the main point of the discussions was to brief NYPA. There was no obvious scenario in which a Fundy to New York State linkage could be envisaged. In any case, policy changes at NYPA were imminent and they would respond if appropriate.

The 28 June 1985 Letter to NEPOOL

This letter is reproduced here in its entirety because of its significance to the entire program.

ALCAN ALUMINIUM LIMITED

28 June 1985

Mr. P. C. Otness
Executive Director
New England Power Pool
174 Brush Hill Avenue
P.O. Box 10
West Springfield, MA 01089

Dear Mr. Otness:

We believe this is the appropriate time to review the recent discussions between NEPOOL and the Study Team which is currently examining the possibilities of a major tidal power station in the Bay of Fundy.

You will recall that we have described to you certain preliminary facts, data and estimates pertaining to such a power development. In brief, we identified as probably the most logical first development a site in Cumberland Basin which alone would yield annually about 3,300 GWh delivered into New England. The designated generation is highly predictable and reliable, being independent of hydro logic events, but of course it is, by definition, cyclic -- producing energy in two six hour periods every day, peaking at about 1,300 MW and with the periods themselves progressively advancing around the clock. The capital cost of the project has been estimated at about U.S.$1.6 billion, including transmission to the Maine/New Brunswick border. This estimate is in today's dollars, excluding interest during construction, and is based on fairly detailed knowledge of the site, the required civil works and the type of equipment necessary. No technological innovations or breakthroughs are involved.

Our initial concept envisaged a simple energy supply to New England, taken as generated, for the purpose of replacing fuel oil that would otherwise need to be burned in your system. You have informed us, however, that this mode was not very attractive to NEPOOL in view of the likelihood that the tidal power would frequently be delivered at times when its usefulness as oil replacement would be limited.

We then examined some possibilities of re-timing the energy in a way that would yield blocks of firm capacity at times of value to your system. The Phase II interconnection with Hydro-Quebec was an obvious candidate but there is not likely to be space on this line until some time after the year 2000. We met with Hydro-Quebec to explore another possibility--utilization of their existing ties to New Brunswick. In principle, this arrangement could be a solution to the re-timing question but there would be a charge, yet to be worked out, for the dedication of a certain amount of capacity for these purposes by Hydro-Quebec. It was recognized that this charge could be significantly lower if the re-timing capacity did not need to be

called upon during critical periods of the Hydro-Quebec system, e.g., January and February. Since such periods might well coincide with the periods when NEPOOL could, in fact, usefully accept tidal energy as generated, it appears that this concept shows some promise.

Finally, we discussed in general terms, a longer-term scenario whereby a strong new power corridor from the Maritimes to New England would be established. Power supplies from new Lepreau nuclear units and one or more major Fundy tidal stations could, starting about 1991 provide a substantial new resource for New England in terms of both capacity and energy. It would appear to give New England another option to meet its future requirements, in addition to the present alternatives of either building new coal-fired stations or importing power from the single other logical source. The installation of gas turbines is, we believe, not a serious long-term solution because of the staggering operating costs that potentially loom.

With regard to the financing of Fundy power for New England--whether alone or re-timed or as part of an integrated complex--we have suggested to you that index-linked bonds must be considered very seriously as the method of choice here. We have already established that, given appropriate power contracts and completion guarantees, ample funds are available in Canada alone for financing a project of this type. The interest rate, of paramount importance to any capital-intensive development, would consist of a real rate of return of about 4% p.a. plus an additional rate equal to current inflation.

Under today's inflation and currency exchange conditions, and allowing for operating costs and amortization, the annual charges would come to a total of about 8% to 9% of the estimated capital investment and would result in a total power cost in 1985 terms in the range of 40 to 50 mills per kwh from the initial Fundy site alone. The price would vary from year to year as a function of the formula governing the debt interest but would always reflect true cost of service. If inflation subsided to zero, the power cost would subside to the range of 30 to 40 mills. In effect, the power would always be priced at a basic figure related to the 4% real interest rate plus an increment, if any, associated with current inflation. In the case of a re-timing arrangement, there would be added charges for the required capacity but, of course, the value of the power supply to NEPOOL would be greatly enhanced.

It is important to note that this financing approach does not alter the basic economics of a power development. At a time, such as the present, when nominal interest rates reflect a real return well above the historical level of about 4%, a project financed via index-linking as described above is bound to appear relatively attractive when compared to conventional financing. What must also be considered is the fact that conventional financing leads to levelized constant revenue requirements while index-linking could result in wide variations in debt service and, therefore, wide variations in revenue requirements. These variations would need either to be absorbed by the receiving power system or passed through as is done for fuel cost adjustments.

It is obviously much too early to go beyond these illustrative figures and conjectures. When we embarked on this study we envisaged that its main purpose would be to set the stage for the comprehensive pre-construction program which would need to be undertaken before final financing and construction could commence. This program would cover matters such as jurisdictional, regulatory, environmental, detailed design and engineering, power contract negotiation, securing necessary completion guarantees, etc. It would likely require three to four years and a cost in the range of $50 million to $80 million. The program, and its expenditure schedule, would be planned in a way that the project could be terminated promptly, and at least cost, should an insurperable impediment be identified.

The structure and funding for this next Stage II phase is not yet formulated although I might mention that one alternative being considered is a private sector consortium of a number of companies which, after bringing the project to the point of ready-to-build, could either continue participating in the construction and operation or could withdraw, receiving adequate compensation for any advance seed money. Conceivably, corporate members of NEPOOL could be part of this group if they desired and if such an investment were statutorily possible.

However, before turning our attention to how a Stage II effort can be launched, we must identify the extent of genuine commercial interest in the final product. Under present and near-term arrangements there is one major Canadian power exporter to both the New York and New England regions. It appears that there is much to be said for encouraging development of a strong second supply to the northeast U.S.A. from Canada. A significant flow from the Maritimes into New England would bring a logical symmetry to the picture, both from a reliability and commercial viewpoint.

At this stage we are not seeking commitments of any kind, nor could we even realistically expect to receive letters of intent. What we do need, however, is an expression of attitude from NEPOOL toward the concepts under discussion. If NEPOOL as such is not in a position to indicate an attitude sufficiently favourable to stimulate our proceeding toward Stage II, then we would likely consider turning to some of the major utilities in your region to ascertain possible interest by them in a direct tidal power supply.

Should it turn out that, for whatever reason, the supply of Fundy power to New England (or New York) is not seen as a mutually advantageous arrangement, then we will probably pursue an all-Canadian approach whereby a re-timed Fundy output would serve as part of the future firm power requirements of the Maritime provinces. This would almost surely have the effect of eliminating tidal power as a New England resource for perhaps a very long time.

As agreed with Richard Bolbrock at our 17 June meeting, I have tried in this letter to explain our position in as candid a manner as possible. He indicated that we could expect a reply from you which would be equally candid and which would help us decide which direction our next initiatives should take.

Yours sincerely,
Murray D. Lester

The 29 July 1985 Letter from NEPOOL
This response to the above 28 June letter sums up NEPOOL's current attitude toward a major Fundy Tidal Power Project.

N E P O O L

July 29, 1985

Mr. Murray D. Lester
Vice President - Energy Resources
Alcan Aluminium Limited
1188 Sherbrooke Street West
Montreal, Quebec, Canada H3A 3G2

Dear Mr. Lester:

RE: Bay of Fundy Project

In your letter of June 28, 1985, you reviewed the recent discussions between NEPOOL and the Study Team which has been examining the possibilities of a major tidal power station in the Bay of Fundy. You also requested an expression of attitude by NEPOOL toward the concepts under discussion. First allow me to apologize for the delay in providing a response. It was caused by our desire to discuss this project with the NEPOOL Planning Committee at their meeting of July 18, 1985 and my just-completed vacation.

The following is a summation of the NEPOOL view toward this project. As you recognize, the simple delivery of the tidal power energy for the purpose of fossil fuel replacement is not attractive to NEPOOL. This is because, first, the cyclic nature of the energy delivery would at times occur during NEPOOL minimum load conditions and cause operational difficulties. Second, NEPOOL requires the addition of firm capacity and energy during the 1990s and not just energy. The Fundy power would therefore have to be retimed in a fashion that would allow it to be counted as capacity. It appears that this would translate into some composite arrangement with Hydro-Quebec and/or New Brunswick.

NEPOOL believes that an arrangement, as noted above, could prove to be an attractive alternative for meeting a portion of NEPOOL's future capacity requirements. We would note that a potential stumbling block could be the ability to obtain regulatory approval of the major additions to the NEPOOL transmission system needed to transmit this new power source to the southern New England load centers. A planning study is necessary to define the extent to which transmission system reinforcements will be required.

In summary, NEPOOL recognizes the potential attractiveness of a retimed Fundy project which provides for firm capacity. While commitments are certainly not possible at this stage of discussion, we see no evidence that an arrangement, which meets both our technical and economic requirements,

could not be developed. I hope that enough insight has been provided to enable you to determine the next course of action. We look forward to evaluating any potential sources of power for the 1990s and beyond.

Sincerely,
Philip C. Otness
Executive Director

Their declaration of interest in firm power makes it clear that re-timing is a fundamental necessity for attracting the New England market under presently foreseeable circumstances. This position was independently confirmed in a separate communication with a senior executive of a major private utility who also serves on the NEPOOL Planning Committee. Obviously, any resurgence in fuel prices, shortage of fuel supplies, expiry of existing power import contracts, or marked tightening of allowable thermal station effluents could serve to stimulate consideration of cyclic tidal power imports. But it is difficult, perhaps impossible, to proceed with a project on such conjectures.

However, if for whatever reason a Fundy project were only viable if its output could be re-timed, the resulting firm capacity ought to be attractive for systems within Canada.

The All Canadian Solution

Reference has been made to the possibility that a re-timed Fundy power source might not require an export market at all but, rather, could form part of the firm capacity that will eventually need to be added to the Maritime Provinces systems. Because a collaboration with Hydro-Quebec is probably the most effective way to deal with re-timing and because Hydro-Quebec may be more enthusiastic about firming up a Maritime supply rather than a New England supply, this revised concept was proposed to Hydro-Quebec.

The 8 October 1985 Letter to Hydro-Quebec

In order to elicit some cost estimates from Hydro-Quebec for the re-timing function and, at the same time, to test whether an All-Canadian approach might be more attractive to them, the following letter was sent.

ALCAN ALUMINIUM LIMITEE

8 October 1985

Mr. Georges Lafond
Executive Vice President,
External Markets
Hydro-Québec
75 Dorchester Blvd., West
Montreal, Quebec H2Z 1A4

Dear Georges:

I am writing to again bring you up to date on the status of the Fundy Tidal Power investigation.

You will recall that we met with you and some of your associates on 13 June, just prior to a planned visit to NEPOOL headquarters. At our meeting with you we discussed, in general terms, the concept of re-timing the generation from the Fundy A8 Project. Its natural cyclic output, totalling about 3,300 GWh per year at rates varying between 0 and 1,300 MW, would be regulated to a firm power supply of, say, 600 to 700 MW for 16 to 18 hours every working day. This re-timing would be accomplished in your hydro system via your DC interconnections with New Brunswick. You pointed out that it was a complicated matter and that, pending further study, your position was neutral.

When the Fundy team met subsequently with NEPOOL, their management reiterated that (a) they are not interested in the energy production available from an un-retimed Fundy Project; (b) they are definitely interested in additional sources of firm capacity and energy starting in the 1990's; and (c) they believe that a Hydro-Québec/Fundy joint arrangement such as mentioned above could prove attractive for meeting a portion of NEPOOL's future capacity requirements.

Since then we have also explored what we term the "All-Canadian Solution", i.e., re-timing the Fundy output as previously noted but retaining the resulting firm power in Canada as part of the supplies that will eventually need to be added to the Maritime Provinces' capability. This concept has obvious merits. For example, it avoids the jurisdictional, legal and regulatory concerns that would be involved in an export arrangement and it eliminates many transmission line problems. We have already provided Hydro-Quebec with certain data relating to load patterns and forecast demands to enable you to examine the effects of this project on an integrated inter-system basis...

We would be very grateful if you could let me know whether or not Hydro-Québec would be prepared to consider the proposed arrangement and, if so, to give us at least a preliminary idea of what the costs might

be. Any additional data or information needed by your people will be provided to them quickly.

Thank you very much for your cooperation to date and for addressing the question we are now posing. We hope it turns out that our efforts some day lead to the linking of two important regions of Canada in a mutually profitable venture.

I look forward to hearing from you.

Very truly yours,
Murray D. Lester

As of the final editing of this Report (27 November 1985) a reply from Hydro-Quebec had not yet been received. We understand they are examining the matter and intend to reply. The issue is further complicated by the impending Quebec provincial elections which could lead to changes in policy and attitude toward the entire question of future power exports and contracts.

CONCLUSIONS

On the basis of more than two years of investigations, analyses and discussions, the Study Team has reported herein its findings and observations. A summary of these, and the conclusions we have drawn from them, are as follows:

1. Modern construction techniques, improved equipment and optimized generating patterns make it possible to install and operate a Bay of Fundy tidal power station at a lower unit cost (inflation-adjusted) than had previously been estimated in the various studies since 1966. There appears to be little chance that additional efforts at technical refinement will yield further major cost reductions.

2. The A8 Site in Cumberland Basin is about 30% less cost-effective than the B9 Site in Minas Basin. Nevertheless, it is believed to be the most feasible initial major project in the Bay. This conclusion is based on considerations of absolute size and capital cost; on environmental factors; and on its bi-provincial nature.

3. The natural tidal rhythms at a power station of the type projected for A8 lead to continuous cycles of generation of about six hours off, six hours on, with peaks of over 1,300 MW occurring approximately every twelve and a half hours. An annual total of about 3,300 million KWh could be delivered to a distant point, with a very high degree of reliability.

4. The selling price of the power depends on a multitude of factors including capital cost, construction period, debt/equity ratio, interest rate on debt, desired return on equity, inflation rate, currency exchange rate, taxes and operating costs. Under certain favourable

but not unreasonable permutations, the delivered price, in real terms, could be in the vicinity of U.S. 4.0 cents per KWh. This pre-supposes, however, one of two financial environments:

(a) that inflation subsides to nearly zero long enough to permit long-term financing to be done at the historic real interest rate of about 4 percent, or

(b) that index-linked financing can be arranged whereby the debt carries an interest rate consisting of a guaranteed component of, say, 4% plus another component equal to current inflation.

In case (b), the power price would vary as a function of inflation rate, in order that annual revenues match debt service requirements.

5. The New England market is not interested in a cyclic power supply such as would be the natural product of an A8 project. This attitude is almost independent of the tidal energy price, particularly at the present time when conventional thermal station fuels are relatively cheap and easy to obtain and when Hydro-Quebec is perceived to be a willing long-term vendor. In addition, the present regulatory climate in the New England states is discouraging vis-à-vis new initiatives of this kind. There would, however, be substantial interest in Fundy power if it could be economically re-timed to a firm supply which could then serve as the equivalent of additional dependable capacity.

6. Re-timing can be accomplished by pumped storage and by other means, but usually at considerable expense. On the other hand, the neighbouring interconnected Hydro-Quebec system could carry out a re-timing function through the use of existing hydro storage and existing or incremental generating equipment. At our request, they are currently examining these possibilities.

7. If re-timing proves to be economic, the resulting firm power from a Fundy A8 project would no longer be dependent solely on the U.S.A. market but could also be an attractive source of capacity in the Maritimes power systems. Many of the jurisdictional, legal and regulatory problems associated with an international export scheme would be avoided. However, the impact on existing local power production traditions (e.g., coal in Nova Scotia, nuclear in New Brunswick) might prove to be an obstacle.

RECOMMENDATIONS

The findings, observations and conclusions reached by the Study Team and reported herein, lead to the following recommendations:

1. The A8 Site should now be recognized and designated as the preferred and most feasible initial Fundy tidal power project.

2. Monitoring and reporting of the prototype Annapolis Royal Tidal Power Station should have a high priority. This will help raise tidal power's image as a viable alternative and will provide information needed to back up a future major project.

3. Contact with Hydro-Quebec should continue in order to be sure that the possibility of re-timing, through their collaboration, is thoroughly explored. In addition, the power authorities in both Nova Scotia and New Brunswick should examine the prospects of carrying out re-timing in those provinces.

4. Continuing contact with NEPOOL would be desirable, to ascertain whether conditions in that system had changed sufficiently to alter their present view toward importing Fundy energy.

5. The scientific community should continue its examination and assessment of the environmental effects of a major tidal project such as A8. A reliable and comprehensive data base will be essential.

6. Unless and until re-timing is shown to be economic, or conditions change sufficiently to make tidal energy marketable as generated, it is recommended that no attempt be made to organize a Stage 2 program.

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